
Nuclear Activity in UZC Compact Groups of Galaxies

M.A. Martinez¹, A. del Olmo¹, P. Focardi² and J. Perea¹

¹ Instituto de Astrofísica de Andalucía (IAA) CSIC

geli@iaa.es, chony@iaa.es, jaime@iaa.es

² Dipartimento di Astronomia-Università di Bologna (Italia)

paola.focardi@unibo.it

1 Introduction

It is well known, and accepted, that environment can play an important role on galaxy formation and evolution, in particular it is expected to influence mass assembly, star formation, morphological evolution and even induce AGN phenomena. Several questions remain, however, open as observational data still lack statistical robustness and give somewhat conflicting results. To properly assess and quantify the environment effect on activation of nuclear activity (AGN and Starburst) in galaxies we have chosen the galaxy systems which have high galaxy density and low velocity dispersion, conditions that maximize the number of gravitational encounters. Compact Groups of Galaxies (CGs) satisfy both conditions and, moreover, being located in low density surrounding environments, guarantee that environment influence may arise only from the galaxy interactions within the CG.

To carry out this study we have chosen the sample of Compact Groups (UZC-CGs) selected by [3] applying an objective neighbour search algorithm to UZC catalogue [2] (Falco E.E., Kurtz, M.J., Geller M.J. et al. 1999, PASP 111, 438). The sample is complete, large (986 galaxies in 291 CGs) and homogeneous and thus particularly suited for our aim. We have, thus, collected available spectroscopic data for UZC-CG galaxies.

2 Archive Data

We have inspected three database archives looking for UZC-CG galaxies spectra. The databases are the Z-Machine Spectrograph Archive, the FAST Spectrograph Archive and the Sloan Digital Sky Survey DR4. We have found 652, 246 and 221 spectra respectively. In several cases the spectrum of the same galaxy was available in more than one Archive, thus the total number of UZC-CG galaxies with spectrum is 868. The vast majority of UZC-CGs (215 CGs)

has spectroscopic full coverage, i.e all member galaxies have a spectrum, and constitutes our Complete (C) sample. UZC-CGs with spectra for more than half member galaxies are part of the Roughly Complete (RC) sample and UZC-CGs with less than half member galaxies with spectra are part of the Incomplete (I) sample. Table 1 summarizes the spectroscopical coverage of the UZC-CG sample giving also information on the number of spectra with emission features in each sample (column 5). However, for sake of completeness, in our study we have made use only of the Complete sample.

Table 1. Available spectra

Sample	Groups	Galaxies	Spectra	Emissions
UZC-CG	291	986	868	543
C	215	720	720	485
RC	47	171	120	75
I	29	95	28	20

Since we do not have homogeneous spectroscopic data we have checked if equivalent width (EW) provided by the three databases are similar.

To do that, we have used the spectra, available for the same galaxies, in the Z-Machine and Fast Spectrograph Archives and Sloan. From Fig 1 we can see that $EW([OIII])/EW(H_\beta)$ and $EW([NII])/EW(H_\alpha)$ ratios are equivalent in the three Archive.

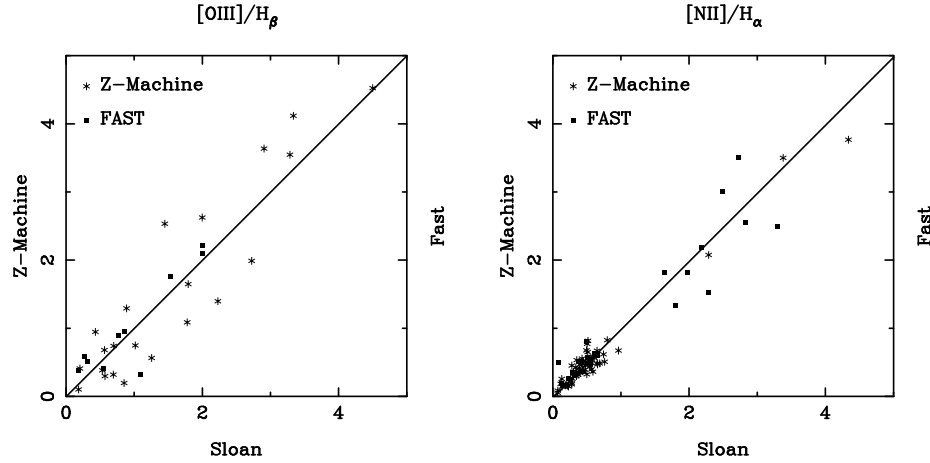


Fig. 1. The equivalent width line ratios in the three Archive data. Solid line corresponds to slope 1 indicating the equivalence between the measurements

We have visually inspected all the spectra looking for the following emission lines: H_β , [OIII] 4959Å, 5007Å, H_α , [NII]6548Å, 6583Å, the two sulphur [SII]6717Å, 6731Å. When the EW were not available in the databases we have measured them, using SPLIT task in IRAF. In cases of high S/N we have measured also the EW of [OI] 6300Å.

Emission line detection depends on spectral quality, in fact the fraction of UZC-CG galaxies with emission line spectra is 58 % for spectra from the Z-Machine Archive, 53 % for spectra from the Fast Archive and 80% for spectra from the Sloan. Since the majority of spectra for our sample comes from the Z-Machine Archive we can safely state that the fraction of emission line spectra in our sample must be considered a lower limit estimate.

3 The Sample

Our Complete sample consist of 215 UZC-CGs (720 galaxies). Figure 2 shows that it is well representative of the whole UZC-CG sample. In fact there is not significant difference between the Complete sample (dashed diagram) and the whole UZC-CG sample(solid line), neither in absolute magnitude nor in morphology. (B magnitude and morphology have been drawn from LEDA databases [8], absolute B magnitude has been computed adopting $H_0 = 70$). Moreover, the two samples have the same fraction (75%) of triplets. We found emission lines in the 67% of the galaxies of our sample. UZC catalogue provides a galaxy classification which should indicate the presence of emission (E), absorption (A) or both (B) features in the spectrum. We found emission lines in all galaxies classified as E or B but also in 131 of the 344 spectra classified as A.

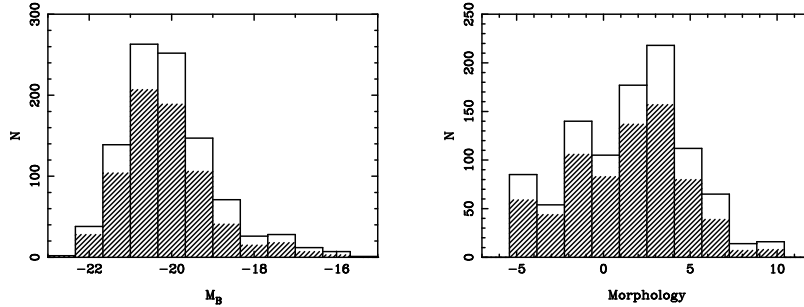


Fig. 2. Absolute magnitude and morphology distributions for the whole UZC-CG catalogue (solid line) and for our sample of Complete groups (dashed histogram).

4 Nuclear Classification

The classification of the nuclear activity has been made mainly using three diagnostic diagrams: 1) $\log([\text{OIII}]\lambda 5007\text{\AA}/\text{H}\beta)$ versus $\log([\text{NII}]\lambda 6584\text{\AA}/\text{H}\alpha)$ or [NII]-Diagram, 2) $\log([\text{OIII}]\lambda 5007\text{\AA}/\text{H}\beta)$ versus $\log([\text{SII}]\lambda 6717\text{\AA} + \lambda 6731\text{\AA}/\text{H}\alpha)$ or [SII]-Diagram and 3) $\log([\text{OIII}]\lambda 5007\text{\AA}/\text{H}\beta)$ vs $\log([\text{OI}]\lambda 6300\text{\AA}/\text{H}\alpha)$ also called [OI]-Diagram, when [OI] was available. Previous works ([4], [5], [7]) have shown the importance of the [NII]-Diagram to do the classification and even, when [OIII] is not detectable, it has been shown [9] that the use of the ratio $[\text{NII}](\lambda 6584\text{\AA})/\text{H}\alpha$ is enough.

In Fig 3 we show the two "main" diagnostic diagrams for the galaxies that have measured fluxes for the the six lines. The lines correspond in light grey to Kauffmann et al. 2003 (hereafter Ka03) sequence for HII nuclei:

$$\log[\text{OIII}]/\text{H}\beta = (0.61/(\log[\text{NII}]/\text{H}\alpha) - 0.05) + 1.3$$

the dark grey lines to the Kewley et al. 2001 (Ke01) sequences:

$$\log[\text{OIII}]/\text{H}\beta = (0.61/(\log[\text{NII}]/\text{H}\alpha) - 0.47) + 1.19 \text{ in NII-diagram}$$

$$\log[\text{OIII}]/\text{H}\beta = (0.72/(\log[\text{SII}]/\text{H}\alpha) - 0.32) + 1.30 \text{ in SII-diagram}$$

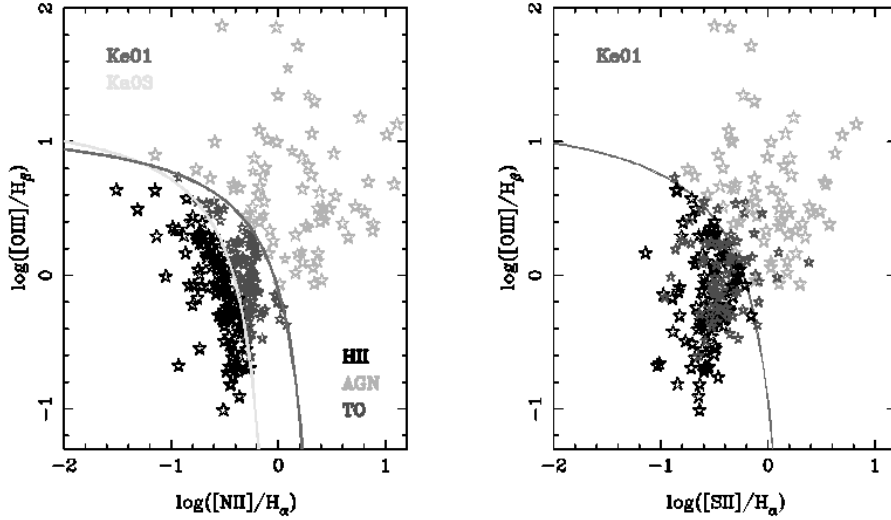


Fig. 3. Diagnostic diagrams to classify nuclear activity. Clear and dark gray lines correspond to Ka03 and Ke01 sequences.

We could not detect all emission lines in every spectra, so to classify nuclear activity we adopted the criteria illustrated below.

- For 260 galaxies it was possible to use both diagnostic diagrams of Fig.3 thus we classified as:

- HII nuclei, the galaxies located below Ka03 and below Ke01 respectively in the [NII] and [SII] Diagram.
- AGNs, the galaxies above Ka03 and above Ke01 in the [NII] and [SII] Diagram.
- TOs, the galaxies lying between Ke01 and Ka03 in [NII]-Diagram and below Ke01 in [SII]-Diagram.
- For 151 galaxies we could compute only the $\log([\text{NII}]/\text{H}_\alpha)$ ratio thus we classified them as:
 - HII if $\log([\text{NII}]/\text{H}_\alpha) < -0.4$
 - AGN if $\log([\text{NII}]/\text{H}_\alpha) > -0.1$
 - classification of galaxies between these two limits was made by visual inspection of spectra looking for the presence of H_β in emission or/and absorption and the detection of broad lines.
- Galaxies showing only [NII] feature were classified as AGNs according to the study made by [1].
- The remaining 6 galaxies without any of the previous ratios available were classified on the basis of the detectable emission lines, the stellar spectral features or the presence of broad lines.

As a result of nuclear classification we found: 180 HII, 210 AGNs and 96 TOs, corresponding respectively to 37%, 43% and 20% of galaxies with emission line spectra. The fraction of TOs is rather large and indicates a high proportion of LLAGNs (Seyfert 2 and LINERs) in UZC-CGs.

5 Nuclear activity and host galaxy

We have looked for possible relation between nuclear activity kind and morphological and photometrical properties of the host galaxy. In table 2 we show the median values of morphology, radial velocity and absolute magnitude (M_B) of galaxies hosting different kind of nuclear activity. In figure 4 we can see that AGNs (dotted line) are located in bright early types and early spirals, HII (dashed line) are hosted in fainter and later types, while galaxies hosting TOs (dotted-dashed line) share properties with AGN and HII host galaxies, in particular they are located in late spirals having high luminosity. Non emission line galaxies are found in the earliest galaxy types.

Table 2. Median values of host galaxy characteristics

Classification	Morphology	Velocity(km/s)	Absolute Magnitude
NonE	-1.0(SO)	5887	-20.3
AGNs	1.1(Sa)	5628	-20.6
TO	3.0(Sb)	5408	-20.3
HII	3.8(Sbc)	4367	-19.8

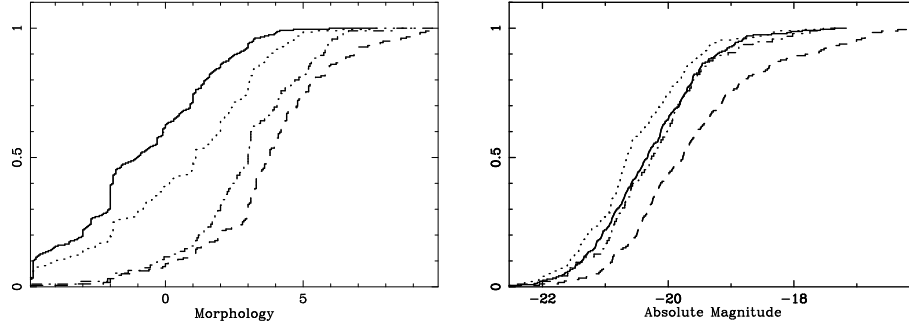


Fig. 4. Nuclear activity in relation with the properties of the host galaxy. Solid line correspond to non emission (NoE) galaxies, dotted line to AGNs, dashed line to HII and dotted-dashed line to Transition Objects (TOs).

The analysis of the incidence of nuclear activity as a function of host galaxy morphology shows that 80% of activity found in early-type galaxies (E+SOa) is AGN. This fraction rises to 92% considering elliptical galaxies only. In Early Spirals (Sa-Sbc) AGN is still the predominant kind of activity but the incidence of HII and TOs is large too. Almost all Late Spirals ($>Sbc$) have emission in their nucleus which derives from Star Formation phenomena. The relationship between nuclear activity kind and morphology is thus confirmed in our sample.

6 Nuclear activity and host groups

We have investigated possible links between nuclear activity kind and CG dynamical properties. In table 3 we list median values of radial velocity, mean pairwise separation (R_p) and velocity dispersion (σ_v) for CGs dominated by AGNs (i.e. more than the 50% of CG members host an AGN), by AGNs+TOs, by HII-nuclei and by non emission (NoE) galaxies. AGN dominated CGs tend to show a larger velocity dispersion and smaller size than CGs dominated by any other kind of activity. HII dominated CGs are the nearest, are larger and have a significantly lower velocity dispersion.

Table 3. Dynamical properties (median values) of CGs dominated by different kind of nuclear activity

	Dominated by v_r (km/s)	R_p (kpc)	σ_v (km/s)
NoE	6468	80	183
AGNs	5569	58	181
AGNs+TO	5892	60	175
HII	3918	74	100

References

1. R.Coziol, A. Iovino and R.R. de Carvalho: AJ **120**, 44 (2000)
2. E.E. Falco, M.J. Kurtz, M.J. Geller et al.: PASP **111**, 438 (1999)
3. P.Focardi and B. Kelm: A&A **391**, 35 (2002)
4. G. Kauffmann, T.M. Heckman, C. Tremonti, J. Brinchmann et al.: MNRAS **346**, 1055 (2003)
5. G. Kauffmann, S.D.M. White, T.M. Heckman, B. Mnard, J. Brinchmann et al.: MNRAS **353**, 713 (2004)
6. L.J. Kewley, M.A. Dopita, R.S. Sutherland, C.A. Heisler, J. Trevena: ApJ **556**, 121 (2001)
7. L.J. Kewley, B. Groves, G. Kauffmann and T. Heckman: MNRAS **in press**, (2006)
8. Paturel et al.: A&A **412**, 45 (2003)
9. G. Stasińska, R. Cid Fernandes, A. Mateus, L. Sodré Jr and N.V. Asari: MNRAS **371**, 972 (2006)